PHA
New approaches

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What is a Process?

- A dynamic interaction between
  - Human
  - Machine
  - Materials

  that include series of actions, changes, or functions bringing about a result.

How do we ensure the safety of the process?

- PREDICTION
  - prediction of all the adverse states of the plant processes
  - recording and
  - evaluating the events' probability, consequences and final impacts

Conventional PHA

- Checklists
- What-if
- HAZOP
- QRA
- FTA
- ETA
- Bow-tie
- LOPA

On base of what we make predictions?

Do they capture the dynamic nature of the systems?

How to catch the dynamic nature of the process?

In most industrial processes, vast amounts of data are recorded through their distributed control systems (DCSs) and emergency shutdown (ESD) systems.

The alarm database

- Most chemical processes have hundreds of variables that monitor their dynamics and they are overlooked and unutilized as it resides in large alarm databases.
- They carry information about belying unsafe conditions.
- Widely applicable process hazard analysis not adequately utilize this information. They focus on the usage of accident databases only.

How to get use of the database?

- Bayesian network or Bayesian analysis
- Bayesian network is a probabilistic reasoning technique that can be very useful to represent complex dependencies between random variables.

How to get use of the database?

Nate Silver - Predicting Trump Election

Sebastian Thrun – Self-driving car

Quantify the uncertainty

- Application of Bayesian network for process safety, accident analysis and risk assessment is relatively new.

- Weber et al. (2012) provides a summary of Bayesian network's application in the field of dependability, risk analysis and maintenance.

Dynamic Risk Assessment Method

- The dynamic risk assessment method herein consists of three steps,
  - near-miss tracking,
  - event-tree and set-theoretic formulation, and
  - Bayesian analysis.

Steps of Bayesian analysis

Set theoretic structure

- Representation of entire abnormal events history of variables

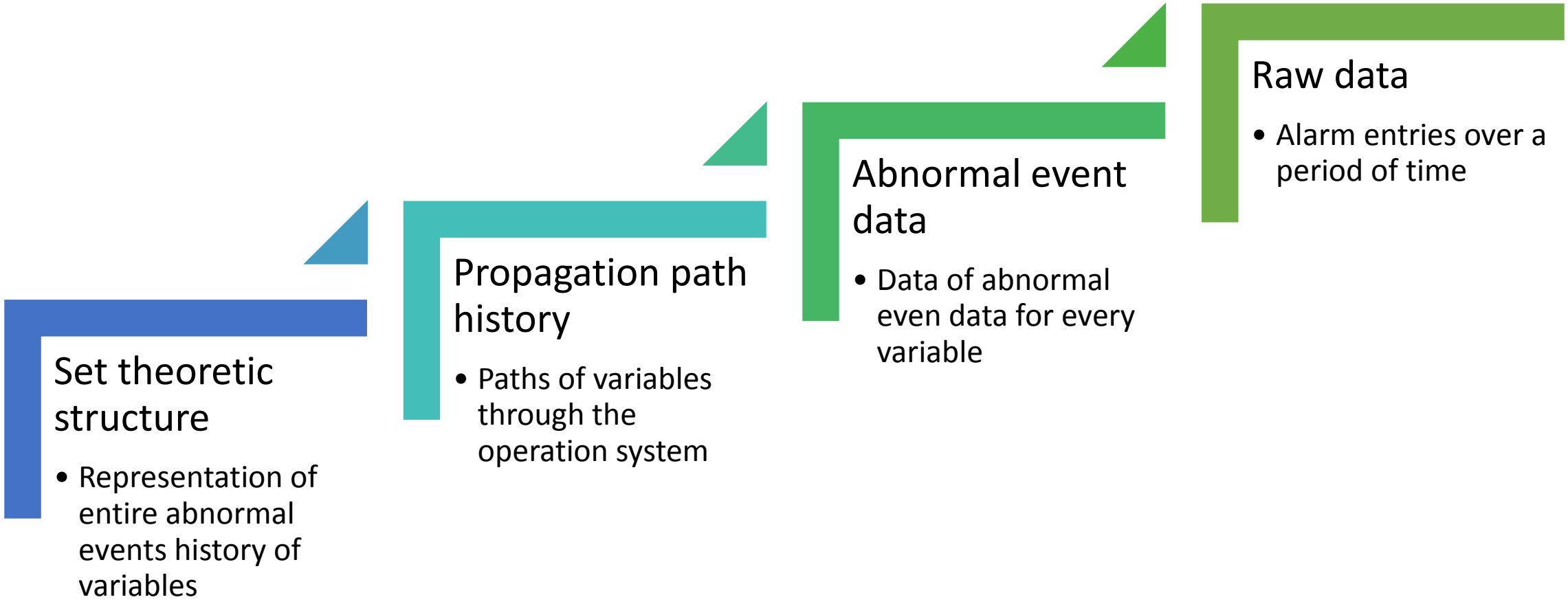
Propagation path history

- Paths of variables through the operation system

Abnormal event data

- Data of abnormal even data for every variable

Steps of Bayesian analysis



Steps of Bayesian analysis

Step 1

Tracking of abnormal events (Near Misses)

- For each variable:
  - Most critical abnormal events
  - Moderately critical
  - Least critical

Step 2 Event tree formulation

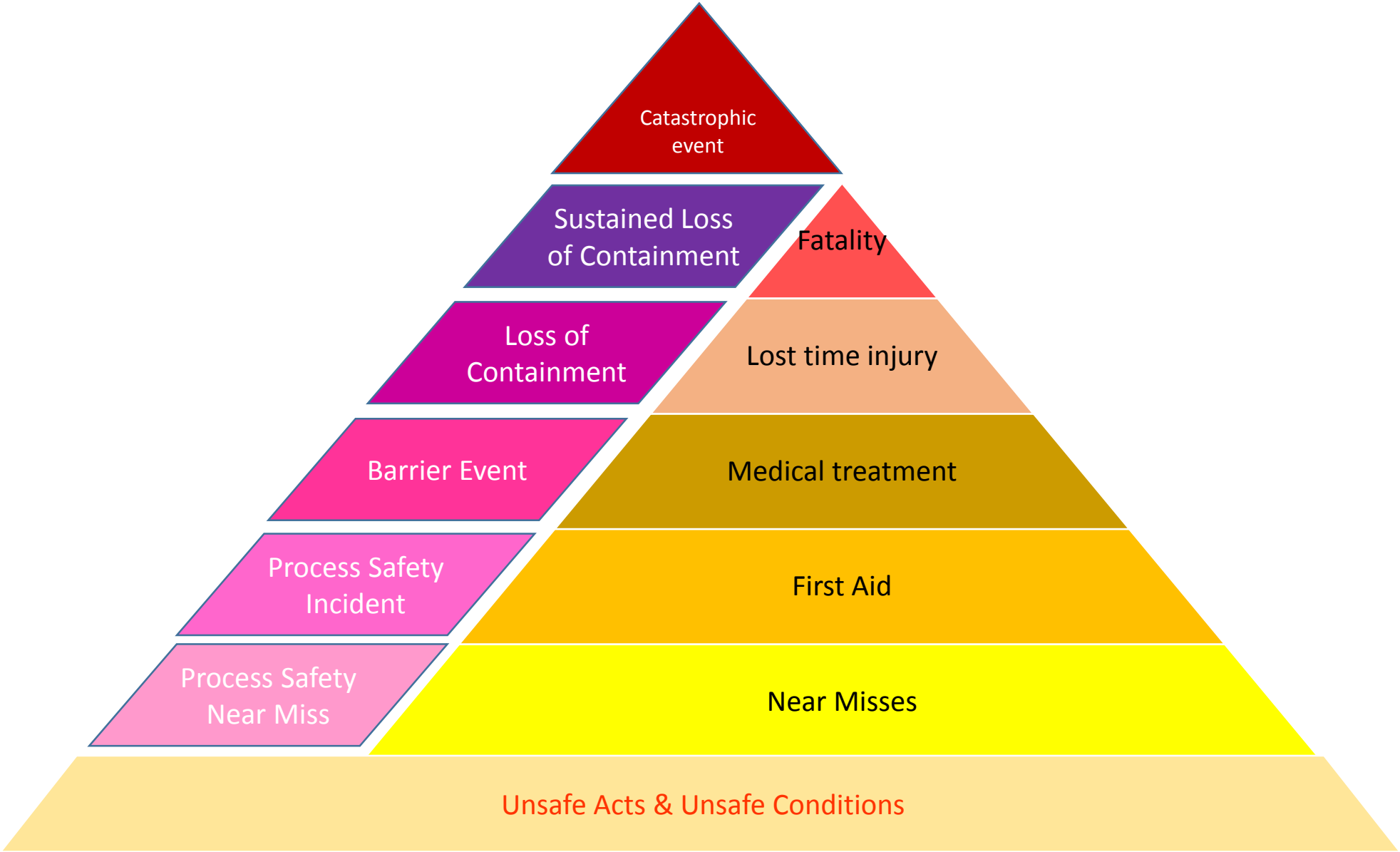
- Process record with paths of propagation

Step 3 Multiset formulation

- Overall abnormal events History

Step 4 Tuple

- Failure or success counts used for Bayesian analysis


Catastrophic event
Sustained Loss of Containment
Loss of Containment
Barrier Event
Process Safety Incident
Process Safety Near Miss
Fatality
Lost time injury
Medical treatment
First Aid
Near Misses
Unsafe Acts & Unsafe Conditions

Process Near Miss

- The parameters' departures from, and subsequent returns to, normal operating ranges are recognized as ''near-misses''—because these departures have the potential to propagate to incidents, when their regulating (process control) and protection (ESD) systems fail. These high-probability, low-consequence events are used to assess the performance and pairwise interactions of their regulating and protection systems and to predict the occurrence of incidents. With this knowledge, potential system problems can be identified and corrected before they result in sizable product and economic losses.

Process Near Miss

- While near-misses directly affect process safety, they also impact product quality, with quality variations significant sources of financial losses in the chemical process industry.

New approach

- Conventional risk assessment methodologies are static in nature. They also have limited ability to quantify different time dependent effects such as, inspection and testing time interval, operator response times and equipment/component ageing.
- The application of Bayesian network to develop a methodology that has the ability to provide continuous update of risk with time.

The challenge

- The safety challenges of the 21st century require an integrative approach that brings fresh thinking and sound practices from across industries and among areas of safety specialization. Lessons from the personal and process safety approaches have revealed the strengths and weaknesses of each.

- Weber, P., Medina-Oliva, G., Simon, C. and Lung, B. (2012). Overview on Bayesian networks applications for dependability, risk analysis and maintenance areas. *Engineering Applications of Artificial Intelligence*, 25(4), 671-682.
- Valeria Villa, Nicola Paltrinieri, Valerio Cozzani (2015). Overview on Dynamic Approaches to Risk Management in Process Facilities *The Italian Association of Chemical Engineering*
- Ankur Pariyani and Warren D. Seider, Ulku G. Oktem, Masoud Soroush (2011). Dynamic Risk Analysis Using Alarm Databases to Improve Process Safety and Product Quality. *AIChE Journal*